BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, DC 20554

In the Matter of	)	
	)	
	)	
	)	
Review of the Commission's	)	MM Docket No. 00-39
Rules and Practices	)	
Affecting the Conversion	)	
To Digital Television	)	
	)	
	)	
	)	

To: The Commission

Comments of the Merrill Weiss Group

Summary

These comments on the FCC NPRM announced as part of the Biennial Review process are intended to provide the Commission with the benefit of the experience of some of

those working to make the Digital Television system come to life. In particular it deals with some of the more technical aspects of the transmission system planning and licensing processes. It focuses on the issues raised by the FCC with respect to service replication and principal community coverage, and it raises the issue of distributed transmission using boosters.

In the NPRM, the Commission seeks to assure that DTV broadcasters do, in fact, replicate their NTSC services so as to deliver programming to essentially the same populations as they currently reach. It asks for a definition of what full replication means. It asks how replication can be achieved and measured. It inquires whether penalties should be applied for stations not reaching full replication of service with the facilities they install. These comments answer those questions and provide suggestions on how to treat the whole issue of replication, from the definition of the term to the appropriate penalties for not achieving it. Fundamentally, full replication is proposed to be reaching the same population as would be reached if a station used its reference facilities from the FCC Table of Allotments and had interference that reduced its coverage.

The FCC further seeks input on the issue of establishment of a principal community minimum signal level for DTV stations to deliver over their cities of license. This is seen as a means to force replication more fully and to improve the availability of signals in the principal community. These comments suggest that it is rather late in the process for some stations to now face Rules changes of such a nature after considerable expenditures of time and money to meet other FCC goals for speedy implementation, collocation, and the like. A principal community coverage requirement could be implemented going forward for those stations that have not already filed for moved facilities. Alternatively, stations could be permitted to provide principal community coverage using boosters in a distributed transmission system that is described later in the comments.

Finally, the comments raise the issue of the use of boosters in what are described as distributed transmission systems to fill in coverage and to maximize service. This is an issue that was first addressed by the Commission in 1992 and on which studies were done

by the FCC's Advisory Committee during 1992 and 1993. The Commission has not yet addressed the matter, and as a result broadcasters are unable easily to use a technique that can have significant benefits in system planning and design. The comments propose a regime for permitting use of distributed transmission systems and boosters, including how to deal with interference, the parameters that should be allowed, and the like.

Among the other technical matters raised by the Commission in the NPRM, these comments do not address the question of the proposal advanced by some to change modulation schemes or at least to allow use of an alternative modulation method. They nevertheless impact on that decision because one of the principal advantages claimed for the alternative modulation scheme being proposed is the ability to take maximum advantage of single-frequency networks, which are an implementation of the distributed transmission systems described herein. Thus the Commission will need to deal with the issues raised and the solutions proposed herein if it is to seriously consider permitting the use of the alternative modulation method. More to the point, though, broadcasters can benefit greatly from the proposals contained herein regardless of the modulation type used.

Introduction

The Federal Communications Commission recently released its Notice of Proposed Rulemaking, MM Docket 00-39, "Review of the Commission's Rules and Policies Affecting the Conversion to Digital Television," Adopted March 6, 2000. In the NPRM, the FCC raised a number of questions about the progress of the implementation of Digital Television (DTV) by broadcasters and about the flexibility to be accorded broadcasters in the locations and facilities of their transmitters. Included among these questions were several related to possible changes in the Rules regarding the facilities that broadcasters may build. In particular, the Commission raised the issues of "Full Replication" and of "Principal Community Coverage." The Commission indicated that it "intend[ed] for this proceeding to be a broad and open proceeding,"[1] meaning that other issues beyond those

[1] NPRM at ¶14.

that it raised itself could be addressed by commenting parties so long as they were not already under consideration in their own proceedings.

The Merrill Weiss Group comprises consultants in electronic media technology, technology management, and management. Having a nine year history in consulting and over fifty years combined experience in the broadcasting industry and related fields, its consultants handle projects ranging from broadcasting to cable, from broadband wireless to advanced video compression technologies, with video and data networking plus data broadcasting in between. Its principal has been involved in the standard setting process for digital television technology from the inception of that work in the mid-1970's, including the entirety of the FCC Advisory Committee process that led to the current standards and Rules.

The Merrill Weiss Group is engaged in the design and implementation of facilities for Digital Television stations that will be directly affected by the Rules changes proposed in the NPRM. It has been working on projects for stations in widely separated parts of the country that nonetheless can benefit from application of similar techniques. In one example, in keeping with the Commission's encouragement of common transmission operations, the Merrill Weiss Group has been working for several years to bring about a common transmission facility at the Mt Wilson antenna farm that serves the greater Los Angeles market. Its efforts together with those of its clients have resulted in the development of new tower capacity on Mt Wilson and in applications being filed for all its clients' DTV operations with maximized facilities and with very low interference between those stations and to other stations. In addition, there are a number of other stations that may be able to locate at the same site as a result of its efforts. It also is planned to move several of the stations' NTSC operations to the common site.

These comments have been prepared to offer to the FCC a greater understanding of the difficulties that some stations face and some solutions that can be applied if only the Commission will allow them. In some ways, the subjects to be discussed are "unfinished business" – matters that the Commission recognized in earlier proceedings but failed to resolve. It is hoped that in the context of the instant review the Commission can deal

with certain matters that will greatly enable flexible solutions to the technical problems confronted by some broadcasters in trying to meet the FCC's expectations.

The Replication Issue

In the NPRM, the Commission raises a number of concerns that it has identified as the result of licensee actions based upon the current Rules. The first of these is the matter of Full Replication. As described in the NPRM, full replication facilities entail a combination of transmitter site, effective radiated power, directional antenna characteristics, and antenna height that are adequate to cover at least the same area as the associated NTSC station covers. The Commission indicated in the NPRM that it had expected eventual full replication on the part of stations even though the Rules contained no explicit requirement for replication. It also expressed concern that the lack of a replication requirement and the lack of the equivalent of a city-grade requirement encourage stations to make long moves of their facilities.

Further in the NPRM, the Commission acknowledged that it encouraged stations to develop common sites where doing so is feasible but then went on to indicate that it expected that "most" stations would build their DTV facilities at or near their NTSC operations. It continued that it did not focus on stations that operate from "fringe" sites at the edges of their markets or that are site-restricted and consequently at a disadvantage with respect to competitors in their markets in terms of service to their markets. It further acknowledged the natural preference of such stations to operate from a central location so as better to serve a larger population.

In prior proceedings, the FCC has also promoted the concept of "maximization" of service by television broadcasters. It has gone to great lengths to develop procedures that support increases in the service areas of stations. These steps have included the techniques defined in OET Bulletin 69, the "*de minimis*" interference limits that circumscribe the extent to which stations can increase their facilities, and the provisions that allow stations to use unusual amounts of beam tilt to permit power increases while avoiding interference. The Commission has recognized maximization as a means to "level the playing field" between VHF NTSC broadcasters that were given UHF DTV

allotments with high powers and large service areas and UHF NTSC broadcasters whose DTV allotments often resulted in lower powers and smaller service areas.

All of this leads to a series of questions that must be answered in order to satisfy the Commission's inquiry in the NPRM. Should DTV broadcasters be required to fully replicate their NTSC service areas? If so, which DTV broadcasters should be required to fully replicate their NTSC service areas? For those that are required to fully replicate their NTSC service areas, what is the definition of such replication? At what date should full replication be required for any stations that are required to replicate their NTSC services? Finally, what consequences should result for stations that do not achieve full replication of their NTSC service areas? We will address each of these questions in succession.

Should Replication Be Required?

Ever since the Commission first pronounced its intention to allow DTV broadcasters to replicate their NTSC service areas, it has simultaneously made provisions for stations to operate facilities that produce service to populations both more than and less than their currently served audiences. Service to populations more than those currently served is achieved through the maximization process previously mentioned and supported by the various interference prediction techniques and limits. Service to populations less than those currently served is achieved by allowing stations to operate with power levels lower than those included in the DTV Table of Allotments. Significantly, when operation at lower power levels was permitted in the Sixth Report and Order, the Commission made no mention of there being any time limits on achieving full replication. The Commission did indicate that it would review this policy at its first two-year review – namely, the instant proceeding.

As a consequence of the Commission's statements that it would not require stations to operate at the power levels indicated in the Table of Allotments, many stations have applied for facilities that can be described as "low power." Although often costing significantly less to implement than full power (as defined by the Table of Allotments) facilities, construction of such "low power" facilities nonetheless generally costs in the

hundreds of thousands of dollars. Moreover, low power facilities place much less of a burden in terms of wind and weight loading on towers than do higher power facilities. This means that many stations can be installed at low power that might not be able to get on the air in a timely fashion at higher power levels because of tower capacity limitations. How many of the stations that have applied for low power facilities are motivated by this limitation is impossible to tell from the applications they have filed, and no other data on this matter is readily available.

Licensees have depended upon the Commission's statements that it would "afford [DTV broadcasters] an opportunity to increase their power over time and thereby 'grow into' the power level needed for full service area replication, as specified in the DTV Table." Furthermore, the Commission put no time limit on the use of lower power levels. It thus seems unfair now to require that those stations increase power in a relatively short period before they have made any real use of their investments in the lower power facilities. In many of these cases, stations have planned or installed antennas and transmission lines that cannot handle higher power levels; this is what reduces the tower loads. So it is not just a matter of putting in a bigger transmitter to increase power levels to achieve fuller service replication.

While it could be argued that many such "low power" stations have not yet constructed and could therefore change their facilities before they are built, this can be quite disruptive to the planning, design, and installation process. In many cases, orders may have to be cancelled, with potential financial consequences such as cancellation penalties resulting. In other cases, different towers may have to be found or built. It is unclear how much the Commission's finding that stations "are facing relatively few technical problems in building digital facilities" would be affected by such a change, but it is certain that some stations will be significantly delayed in their implementations if they were forced to implement at higher power levels within a short number of years.

The simple answer to the question posed by the Commission as to whether replication should be required is no, that it should not be — certainly not anytime soon. Too many broadcasters have depended upon the Commission's pronouncements that it would allow

them to start out small, with no time limits indicated. Often, these broadcasters are the ones that are marginal in their financial situations, thus making it all the more difficult for them to change their planning in mid-stream.

When or if to fully replicate can be a marketplace-driven decision on the part of broadcasters. When consumers have transitioned to DTV receivers to the extent that broadcasters must increase service areas in order to reach their audiences, they will do so if they wish to stay in the broadcasting business. There seem to be no markets where all broadcasters have chosen the low power approach, so permitting such a natural migration should not constrain the availability of DTV service to the general population. Only certain choices will be unavailable for some viewers.

Which DTV Broadcasters Should Be Required to Achieve Replication?

Should the Commission not accept the simple solution offered immediately above not to require full replication at this time, then it must answer the question as to which stations should be required to achieve full replication. A simple answer would be to require all stations to achieve full replication at the time decided in answering the question that is addressed two sections below. But such an approach would be unfair to some stations and might be counter-productive relative to the FCC's goals.

In deciding the stations from which to require full replication in the short term, the FCC should take account of those stations that have depended upon the Commission's earlier pronouncements. Those that took action based on the Commission's indication of the desirability of moving to a common transmitter site and those that have made commitments that are not easily reversed for equipment or other facilities that fall short of full replication should not be penalized. It is not right to change the rules in the middle of the game. Thus, where stations have spent substantial time and effort performing interference studies, designing facilities, and applying to the Commission for construction permits to move to common sites, they should be allowed to proceed on the basis of the Rules as they exist. Those that have not completed such efforts and any stations applying in the future could be required to achieve full replication, as that term comes to be defined. To determine which stations would be granted such consideration, the

Commission might establish a cutoff date, such as the date on which the Report and Order in the current proceeding is released, prior to which such applications would have to have been filed.

Another factor that the Commission should recognize is that some of the moves to common sites are dependent upon several stations moving together in order to mitigate interference that otherwise would occur. The benefits of commons sites include the fact that, in a system using outdoor antennas or somewhat directional indoor antennas, viewers do not have to move their antennas from transmitter site to transmitter site as they tune. Viewers are accustomed to simply switching channels and having the signals appear. This is especially true of cable and direct-to-home subscribers. Since broadcasters cannot count on cable or satellite carriage of the DTV signals at any time in the foreseeable future, they must compete in the digital television environment using their off-the-air signals. This means they must be tunable instantly by viewers, which means they must be at common sites, where they exist, or risk being left out of many viewers channel selection process.

An additional benefit of common sites is that collocation of stations is one of the best ways in which to mitigate interference between stations that otherwise would be too damaging from each to the other's coverage. Thus, where stations have chosen to collocate in order to mitigate interference, and forcing one of them to replicate coverage might preclude one or more other stations from achieving the benefits of locating at a common site, the Commission should relieve any replication requirement for one station in order to benefit the others and their respective audiences.

What Is the Definition of Full Replication?

Should the Commission decide that a requirement for full replication is necessary, then that term must be defined in a technical sense. There are several ways in which it can be defined, for example: based upon area or population, based upon signal contours or terrain-sensitive propagation models, and/or based upon absolute values or proportional coverage. To the extent possible, the methods employed should be similar to those already used in the studies for determining coverage, interference, and the like.

In all of the studies of coverage and interference since the beginning of the work on the Table of Allotments, it has been population that has been determinative of service. The physical area covered by a station has served only as a limiting factor for population studies, never as the determining element. That practice should be continued in the determination of full replication. Contours, such as the NTSC Grade B contour and the DTV Noise Limited contour, should be used only to decide what areas are appropriate to study. The population reached within those contours should be the deciding factor in whether full replication is achieved.

The Commission has raised the full replication issue with respect to two particular circumstances with which it is concerned. The first is the case of stations that operate with lesser facilities (principally lower ERP and/or lower antenna height) than were included as reference values in the Table of Allotments. The second is the case of stations that move their transmitters significant distances from their reference locations (generally their NTSC transmitter sites). Different definitions may be required in these two cases, but they can be related to the same criteria.

It should be recognized that the FCC, in establishing the concept of *de minimis* interference limits, gave to other stations in the aggregate the right to reduce the service in terms of population of a particular station. Other stations together may reduce such service to the extent of ten percent without the subject station having any right to object. The reduction is allowed to permit those other stations to improve their own service areas, for engineering convenience, or for any other reason. Why should other stations have the right to reduce a station's service for their own reasons and the subject station itself not have similar rights? Thus the Merrill Weiss Group's proposal in response to the Commission's question about what constitutes full replication is that it is the reference population in Appendix B to the Second Reconsideration Order[2] less ten percent.

Application of the proposed value would differ somewhat in the two cases posed. Where a station proposed to operate with lesser facilities but at essentially the reference site

[2] Appendix B of the Second Memorandum Opinion and Order on Reconsideration of the Fifth and Sixth Report and Orders in MM Docket 87-268, 14 FCC Rcd 1348 (1998), herein the "Second Reconsideration Order."

assumed in Appendix B, the station would be considered to have achieved full replication when it was capable of reaching 90 percent of the reference population defined in Appendix B. When a station achieved this level of service, it would be treated for interference analysis purposes as though it were using its reference facilities. Any reduction of its service as a result of interference from other stations might reduce its service further. The total reduction of service could be as high as 20 percent in the extreme case in which the station potentially reached 90 percent of its reference service population and other stations contributed to a total of 10 additional percent of service reduction through interference.

Where a station proposed to operate from a significantly different location than its reference facilities, it would be required to reach 90 percent of the actual population served by its NTSC station. How that value is determined would depend upon a decision between the use of contours or the use of a terrain-sensitive model for the calculations; both methods will be described in detail. The propagation model used for all other interference and service analyses associated with DTV is the Longley-Rice model, and its use is recommended for this application as well, should be Commission decide not to use the contour approach. Its use will be assumed for this discussion.

In the case of the contour method, two contours would be calculated. The Grade B contour of the NTSC facility would be modified by the effect of the dipole factor and called the NTSC Noise Limited contour in keeping with the terminology of OET-69. (The population within this contour is the NTSC reference population used in studies of interference to NTSC stations.) The Noise Limited contour of the proposed DTV facility would also be modified by the dipole factor. The population within the NTSC Noise Limited contour would be calculated. The population within the Noise Limited contour of the proposed DTV facility that was also within the NTSC Noise Limited contour would similarly be calculated, i.e. the population within the overlap area of the two contours. The overlap population would have to be at least 90 percent of the NTSC Noise Limited population in order for full replication to be considered achieved. In this case, interference would not be considered.

Should the Commission decide to use the propagation model approach, the process would be similar to the contour method except that the populations involved would be calculated using the methods of OET-69 and interference would be considered. In this instance, the population within the NTSC Noise Limited contour (Grade B modified by dipole factor) that is reached by the NTSC station without interference would be calculated using the Longley-Rice method according to OET-69. Similarly, the population within the NTSC Noise Limited contour reached from the proposed DTV facility without interference would be calculated using the Longley-Rice method according to OET-69. The population reached within the NTSC Noise Limited contour from the proposed DTV facility without interference would have to be at least 90 percent of the population reached within the same contour from the NTSC facility without interference in order for full replication to be considered achieved.

Using either of the methods described, the population that a station would reach from a proposed DTV facility at a different site from its NTSC facility would have to include 90 percent of those receiving its NTSC signal. This is essentially identical to the result in terms of population served as under the combination of the Commission's allotment plan and the *de minimis* interference rules. It assures that the Commission's concerns about significant populations being left unserved after the DTV transition would be completely addressed. Yet it offers DTV broadcasters the opportunity to use engineering creatively to meet limitations in tower space availability or to improve their overall service. The replication analysis techniques proposed have been tested and found to be no more difficult to implement than any of the other procedures involved in the DTV license application process, such as those prescribed in OET-69.

For stations that do not have a paired NTSC channel, replication is a misnomer. Nevertheless, the reference facilities for such stations should be protected if they achieve service to a population level equal to or greater than 90 percent of that predicted for the reference facilities included for them in the Table of Allotments. This treatment is consistent with that applied to other stations having paired channels, as just described.

At What Date Should Replication Be Required?

As stated previously, it is the position of the Merrill Weiss Group that replication should not be required but should be driven by marketplace considerations. Nevertheless, should the Commission decide that some sort of date certain is required, then the date should be derived from one of several categories depending upon each station's particular circumstances.

For those stations that have not yet taken steps that are irreversible without financial loss and that have not filed applications to move sites based upon the Commission's earlier decisions, then a date such as the end of the transition, whenever that occurs in a station's market, would be appropriate. For those stations that have made a significant financial commitment that is irreversible without financial loss, the end of the depreciation period on that investment or the end of the transition in a station's market, whichever is later, would be appropriate.

There are some stations that have depended on the Commission's earlier decisions and have done the engineering work to move their facilities, as evidenced by their applications already having been filed. For those that applied by some specific date, (perhaps the date of release of the current NPRM) the requirement to fully replicate should become effective when they move from the site for which they have already applied, assuming that they qualify for that site under the Commission's existing Rules. By the Commission's own words, "Most of the DTV applications that have been filed and granted thus far are for locations at or near their current NTSC antenna sites." Only "several licensees have sought authority to move their DTV station to a more central location in their market or toward a larger market." Thus the problem is relatively small, and the replication requirement going forward for those that have not yet applied for such a move will keep it so.

What Should Be the Consequences of Not Achieving Replication?

For some broadcasters, the problems of achieving replication can be great. This can occur when stations are in poor financial condition or when adequate tower space is not readily available, as, for instance, in some well-known, difficult zoning situations. For

those stations, the greatest penalty is the loss of their audience that results from their own failure to reach it. Additional remedies in such cases may prove to be counterproductive.

The recommendation of the Merrill Weiss Group is that the only consequence of not achieving replication should be the loss of protection to the portions of the replicated service area not served by the facilities actually constructed for such time as they are not served. Thus for stations that achieve less than full replication, as defined above in the section on that subject, unless and until such time as they achieve full replication, only the areas they actually serve should be protected from additional interference from other stations seeking to increase their facilities. When a station that did not achieve full replication later seeks to increase its facilities, it should be able to do so, so long as it protects facilities that may have been approved by the Commission that do not protect its replication facilities. From then on, it should be protected to the extent of the facilities it constructs. If it eventually is able to build full replication facilities, as defined above, then it should receive protection to its reference allotment or to any greater facilities that it is able to construct.

The approach recommended follows the long-standing Commission policy of protecting licensed or applied-for facilities from later applications. Similarly, those later applications should be protected from others filed at an even later date. Such a rolling cutoff mechanism should be put into place immediately following the completion of authorization of the initial batch of applications currently on file. The method for resolving any mutual exclusivity among applications in that initial batch is beyond the scope of these comments.

Principal Community Coverage

In addressing its second major concern resulting from licensee actions based upon the current Rules, the Commission offers several reasons for proposing that a higher signal level than the noise limited threshold be required over a DTV station's principal community. Among these are that it would create greater consistency between the DTV and NTSC services, that it would serve as an indirect means to force a higher degree of replication of the NTSC service, and that it would result in a higher degree of availability

in the principal community. It then proposes certain increased levels of signal over the principal community and proposes to delay the requirement for implementing such a signal level for one year after the scheduled completion of construction.

Once again, this is a case in which the Commission set the rules when it began the DTV implementation process and gave little or no indication that it would impose higher signal level coverage requirements for principal communities. As a result some stations have spent years of planning and design efforts, at considerable expense, developing solutions to their coverage issues that may not be able to produce the signal levels that the FCC is now proposing. In at least some of these instances, the resulting moves solve interference situations that allow several DTV stations to maximize their services jointly where they could not individually. This result is achieved through collocation at a common site – a technique well known to mitigate many interference situations. As in the matter of replication, this is a case of the Commission proposing to change the rules in the middle of the game. The effect of doing so can have impacts on actual situations that are counter to the interests that the Commission is trying to promote.

Take, for instance, the case in which a station has an NTSC Noise Limited contour that covers a highly populated area, giving the station a very large population within that contour. Further analysis of that station using the Longley-Rice method, which, although not perfect, much more closely represents the reality of propagation to be expected than the simple contour approach, shows that the station actually serves only a small proportion (<25 percent) of the population within its NTSC Noise Limited contour. Moving the transmitter of the station under consideration to a site further from the city of license results in a very substantial improvement in the population actually served (on the order of 3x the population served from the NTSC transmitter site). This improvement occurs because of the impact of terrain on propagation from each site. The improvement occurs within the existing NTSC Noise Limited contour as indicated by the Longley-Rice method (and other, similar propagation analysis tools) and without counting any increases in service to areas outside the original NTSC Noise Limited contour. Thus the new site results in a major increase in "replication" of the NTSC Noise Limited service that the FCC uses as a reference, beyond what was actually achieveable from the NTSC site. The

one negative factor about the site change is that it is not possible within the currently allowed power limits to achieve the proposed "city grade" signal levels over the city of license from the site that results in the dramatic improvement in replication.

It so happens that the city of license of the station under discussion is next to the ocean. So moving the transmitter close enough to the city of license to produce the proposed "city grade" signals would result in producing a very large, wasted signal level over the ocean. Much of the station's power would go to producing forced "replication" over an area that can never have more than a very few viewers and where much of the NTSC signal is currently wasted. The actual population served within the station's existing NTSC service area would be much lower than from the station's proposed site. The proposed site, moreover, is a common transmitter site for a major metropolitan area to which all receiving antennas point. Not moving to that site will put the DTV station at a further disadvantage even in its principal community because it will be located elsewhere than all the other stations in the region. Coincidentally, the station not moving will also mean that another station that is dependent upon collocation with the subject of this example will not be able to maximize its service.

The Commission has noted the high cost to broadcasters of installing transmission facilities for DTV. A question that must be answered is whether it is better to force a minimum signal level over the city of license, while at the same time squandering a very expensive resource, or to allow a lower signal level over the city of license if a much higher degree of replication and of service can be obtained. This is a real example and a real set of circumstances.

Let us consider now the Commission's reasons for proposing a higher signal level over the principal community in the light of the example given. First, the consideration of producing greater consistency between the analog and digital services is specious from the start. The two services use quite different technologies and have rather different performance characteristics, as outlined in the NPRM itself. To force them to obey the same rules for the sake only of "consistency" is to deny their fundamentally different natures. The issue of "availability" is more substantive and will be addressed shortly.

As discussed previously in the section on The Replication Issue, in many cases, licensees have played by the rules that the Commission has promulgated for the past four years and have developed solutions to service problems that conform to those rules, often at great expense. Now to throw out the existing rules in favor of something new will in many cases result in wasted time and effort and in some cases service problems that are difficult or impossible to resolve. A better approach is to let those stations that have worked within the existing rules and that have filed timely applications meeting the requirements for maximization proceed with their operations without penalty, even if they cannot produce a "city grade" signal over their principal communities. If those stations eventually move their stations again, perhaps they should not be allowed to move further away and to produce any lower signal levels over their cities of license. Those stations that have not yet applied to make such changes could be held to the new rules that the Commission might now promulgate.

The requirement for producing a "city grade" signal level over the city of license was portrayed as a back-door way to force stations to replicate their current NTSC services. As was described in the section above on The Replication Issue, there are much more direct means for assuring that the goal of replication is met and of measuring performance in that regard. Thus the indirect approach to that goal through a requirement for city grade signals is unnecessary and inappropriately burdensome. The methods suggested above for evaluating replication have been shown by actual use to be no more difficult to carry out (and in some cases easier) than any of the interference prediction methods already used in the DTV license application process, such as those of OET-69.

The portrayal of the requirement for a city grade signal over the city of license as a means for assuring that a higher level of signal availability and reduced interference will be achieved in the principal community is correct. Such a requirement can produce the sought-after results. An important question is whether this is always the best goal to be promoting. As shown in the example case cited above, requiring a city grade signal over the city of license can result in an actual reduction in service to the area intended to be served through replication of the NTSC service along with simultaneously wasting signal produced at great expense. If it is deemed necessary by the Commission to force DTV

broadcasters to deliver signals in certain places, it would seem better to focus on the replication requirement than the principal community requirement. This is likely to result in the highest level of service to the greatest number of viewers. At the very least, the Commission should provide a procedure by which a lower level than the 16 dB premium at UHF (40x the power) can be reduced when other factors indicate that the best service to the public will result from allowing a specific move to occur. For instance in the example case cited above, a recognition of the impact of the move on more than one station's ability to maximize, of the move to a common site as encouraged by the Commission, and of the meeting of the replication requirements as defined above are all factors that point to such a move being publicly beneficial. In such an instance, the additional power required over the principal community should be reduced to 6 dB above the noise limited threshold, which is sufficient to deal with many fading effects.

In the end, if the FCC considers it necessary to enforce both a replication requirement and a principal community requirement, then it should allow DTV broadcasters to take advantage of all the engineering tools available in meeting those requirements. The fact that the operations under discussion are digital enables a range of solutions that are not available for analog systems. In particular, with digital operation it becomes possible to apply multiple transmitters on the same channel to obtain coverage in configurations not hitherto possible. Multiple transmitters can be used to build so-called "single frequency networks" that have been associated mostly with certain advanced modulation techniques that the Commission is coincidentally considering as part of the instant proceeding, but they can also be applied to conventional digital modulation methods. These techniques, along with the conditions under which they can and should be allowed, are discussed in detail immediately below in the section on Use of Distributed Transmission & Boosters. The Commission, then, should not mandate that both replication and principal community coverage requirements be met only through use of a single transmitter but should allow application of distributed transmission techniques to meet the requirements as well.

Use of Distributed Transmission & Boosters

Signal boosters of one sort or another have been in use in a variety of services for many years. They have even been available to NTSC television broadcasters under the FCC Rules. But they have been permitted under assumptions about the transmission system that no longer need limit the way that systems are designed. The very term "booster" and the secondary status boosters are accorded carry an implication that there is to be a main station intended to reach the bulk of a station's viewers and a supplementary transmitter intended to deal with out-of-the-way, perhaps expendable portions of the station's service area.

The digital techniques used and enabled by the Commission's establishment of a Digital Television (DTV) service open a whole range of capabilities not envisioned by the Rules for analog service. So, too, the economics of data transmission through terrestrial fiber optic networks to multiple transmission sites now enable transmission systems that can better reach viewers at costs that are reasonable for broadcasters to absorb. This economic situation has changed only in the last few years and sheds a new light on conclusions about distributed transmission reached by the FCC Advisory Committee on Advanced Television Service (ACATS) not too many years ago.

The Commission has had inputs on the use of distributed transmission and boosters before. In the Memorandum Opinion and Order/Third Report and Order/Third Further Notice of Proposed Rulemaking released on October 16, 1992, it specifically asked about such methods. In that Notice, the Commission indicated that it was awaiting the results of work undertaken in ACATS to help it decide how to deal with the matter. The Advisory Committee, through its Implementation Subcommittee Working Party 2 (IS/WP-2) on Transition Scenarios studied the techniques and issued several reports. There was inadequate time as ACATS was shutting down, however, for IS/WP-2 to prepare a complete report to the Commission on the subject. As a consequence, a report to the FCC was requested by IS/WP-2 to be submitted as individual comments by the

leader of the Working Party's activities over its five-year life.[3] Subsequent to that report, a number of comments submitted in response to the Sixth Further Notice of Proposed Rulemaking[4] expressed concerns that stations' should be able to use boosters in a manner that really amounts to distributed transmission as it will be defined shortly. The Commission has not yet seen fit to address these issues.

Distributed transmission and boosters are techniques that can offer solutions to a number of difficult system design problems that often can be resolved in no other way. They have applications to reach blocked populations within a station's service area; this is especially important in hilly or mountainous terrain with populations living in valleys. They can be useful when a station is unable to obtain sufficient tower capacity at an adequate height to reach the service area that has been allotted to it. They can be used when a station has started with a small service area and needs to expand without enlarging its central facility. They can be used to deal with situations such as the example given earlier, in the section on Principal Community Coverage. In that instance, the best site for reaching the population within the station's existing NTSC contour is at too great a distance from the principal community to achieve the increased signal levels sought by the Commission for such cities of license.

The Commission should recognize that licensees are making long-term decisions and investments now. In order for stations to achieve the best possible results for the audiences that they serve, they should be enabled to use all the techniques that modern technology and the economics of the marketplace allow. This will best meet the Commission's goals of DTV delivery to the widest possible audience at the earliest possible time. It will also enable the Commission's other, oft-stated objectives for the DTV service of common site operations, station collocation, and service maximization. Not having such techniques available for use now can lead to decisions that are expedient in the short term but sub-optimal in the long term.

---

[3] See Comments of S. Merrill Weiss, Consultant, In the matter of Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service, Memorandum Opinion and Order/Third Report and Order/Third Further Notice of Proposed Rulemaking, released October 16, 1992.

[4] See Sixth Further Notice of Proposed Rule Making, MM Docket No. 87-268, 11 FCC Rcd 10968 (1996).

It should also be noted that use of distributed transmission and boosters are among the principal techniques that can make the COFDM modulation scheme function most advantageously. If the Commission is serious in its consideration of that method, it must also consider distributed transmission. Without getting into the merits of one modulation system over the other, it should be understood that distributed transmission and boosters can be used beneficially with either COFDM or more conventional digital modulation methods, perhaps with better or poorer results, but to good advantage nonetheless.[5] Thus in many ways, the time has arrived for the Commission to take up this hitherto unfinished business.

Distributed Transmission Defined

For sake of explanation, distributed transmission can be likened to a cellular telephone system. The service area is divided into a number of cells, each with its own transmitter. The transmitter powers can be much lower than that of a single, central transmitter. Lower tower heights can also be used than when covering a large area from a single site.

The major difference between cellular telephone systems and distributed transmission is that cellular phone systems divide the spectrum into three or more channel groups, with individual cells using only one of the groups. Cells are assigned channel groups in a pattern that assures that no adjacent cells share the same channel group. In broadcast television transmission, there will be no additional channels available to establish such an alternating assignment pattern. Instead, there will have to be a single-frequency network (SFN), with all transmitters on the same frequency. It is to emphasize this difference that the term "distributed transmission" is used here instead of "cellular television."

What makes distributed transmission possible is the fact that all digital receivers, from the biggest television receivers to the smallest set top boxes, require a means for dealing with echoes ("ghosts," in NTSC terms). Echoes in received digital signals normally cause inter-

[5] In fact, the original submission to the FCC on the subject was included in the certification documentation submitted to the Advisory Committee in late 1991 by the American Television Alliance for the Channel Compatible DigiCipher (CC-DC) system, a 32-QAM modulation method. See also S.A. Lery, W.H. Paik, and R.M. Rast, "Extending HDTV Coverage Using Low Power Repeaters — A Cellular Approach," IEEE Transactions on Broadcasting, Vol. 38, No. 3, September 1992, pp. 145-150.

symbol interference (ISI) that can make it impossible to properly interpret whether a received symbol represents one value or another. There are two primary methods for dealing with the echoes: (1) adaptive equalizers in the receivers, or (2) a particular form of modulation called orthogonal frequency division multiplexing (OFDM), of which the Commission is currently considering a specific variant, Coded Orthogonal Frequency Division Multiplexing (COFDM).

Since digital receivers will have the ability to handle echoes and since multiple signals arriving at a receiver from adjacent cells of a distributed transmission system are required to have precisely the same modulation on them, such signals can be treated as a series of echoes. The receiver will then adapt to the "echo" environment, extracting the correct data from the ISI-laden received signals. It is this echo elimination that really makes the distributed transmission / single-frequency network concept feasible.

For the FCC's purposes and for the remainder of these comments, distributed transmission can be defined as the use of more than one transmitter on a single frequency as part of a system to deliver a single signal to a service area. Use of boosters can be treated as a subset of the distributed transmission concept. The definition leads to a number of issues, largely technical, that must be addressed in order to enable the use of the subject techniques, but it will inform the remainder of the discussion on this matter.

System Design Issues

For the distributed transmission concept to work, there are a number of prerequisites. Foremost among these is that all of the transmitters must produce identical signals in the sense that they radiate the same symbol codes in the same order for the same data input. This keeps all the signals coherent with one another so that to the receiver they appear as echoes of the same signal. This coherency is necessary for both conventional and COFDM modulation techniques and allows desired-to-undesired, or D/U, signal level ratios between the various transmitters to approach or reach 0 dB.

If the signals were not coherent, it would be necessary to treat them as true interfering signals, maintaining the required D/U ratios (on the order of 15-20 dB) between

transmitters as seen by the receivers. For conventional modulation, it nonetheless helps to use terrain shielding between transmitters whenever possible so as to minimize the burden on receivers by reducing the strength of echoes. This is arguably not the case for COFDM, which is claimed to work as well or better with echoes as without.

There are several other considerations about the ways in which distributed transmission systems and boosters are implemented that can have significant impacts on the benefits that can be derived from use of the techniques. Certain characteristics of receivers also come into play. Among the most important of the implementation aspects for transmission is the means used to feed signals to the transmitters. There are two fundamental methods: over-the-air by relaying from transmitter-to-transmitter, and using a separate delivery system such as a microwave channel or fiber optics.

When over-the-air relaying is used, there is very little control over the relative timing of the emission of the modulation symbols. The timing depends only on the physical separation of the transmitters one from another, the speed of radio wave propagation, and any delays through amplifiers and filters in the repeater receiver/transmitters. Another consideration with over-the-air relaying is that there are physical limits to the amount of power that can be transmitted because of the tendency of the receiving and transmitting antennas to couple signals, leading to feedback if too much gain is used to raise the transmitted power level. It is also much more difficult to transmit a signal without noise from a transmitter that has received its input signal by relaying since the signals, once modulated, are fundamentally analog in nature, being interpreted back to bits in the receiver.

When a separate delivery system is used, some transmitters can be delayed in their emissions in order effectively to advance the timing of others. Such adjustments, along with the spacing of the transmitters from one another, in turn, will impact the length of adaptive equalizers needed in conventional receivers and the length of the guard interval required by COFDM receivers. Through adjusting the relative timing of the transmissions, it is possible to optimize the system so as to minimize the burden on

receivers regarding the echoes they must correct or ignore. It is also possible to transmit signals with no noise addition from the delivery system.

Issues for FCC Rulemaking

Despite the many considerations that must go into the design of systems using distributed transmission and booster techniques, many of these matters are beyond the need for FCC rulemaking. Rather, what is important is for the Commission to permit as much flexibility as possible in the design of such systems and to focus on Rules that enable the widest range of application possibilities while still assuring the appropriate levels of interference protection to and from neighboring systems.

A number of issues seem ripe for Commission attention in regard to regulation of the use of distributed transmission systems and boosters. (For purposes of this portion of the discussion, all transmitters in a distributed transmission system other than the primary or reference transmitter shall be referenced as "boosters.") Among the issues requiring rulemaking are the locations in which boosters may be installed, the primary or secondary classification of boosters, the power levels and other technical characteristics that may be used, any limitations on the areas that may be covered with boosters, interference protection to be afforded other stations, interference protection to be afforded stations using distributed transmission systems, and the methods for determining the coverage and interference protection predicted.

Before proceeding further, it will be helpful to consider the purposes that distributed transmission systems and boosters will serve. First, they will serve all the purposes that boosters historically have served filling in gaps in coverage. In addition, they will serve to extend the coverage of the primary stations with which they are associated in the same way that translators historically have done in the past. This will help with the problem that sufficient spectrum is not available in most places to be able to replace translators when they are displaced by new, digital full service stations, let alone to duplicate the coverage of most existing translators. They can also be used to allow a broadcaster to create "hot spots" in its signal strength over areas where such increases in signal level can be beneficial or to achieve a more uniform range for its signal level.

Primary and Secondary boosters

There are two fundamental ways in which boosters can be installed. They can be included in the system used to cover and extend a station's primary service area, and they can be used to provide service to locations clearly outside that service area, as translators have done for many years. When they are used to cover and extend the primary service area, they should be given primary status and protected from the signals of other stations in the same way that a single transmitter would be. How to provide such protection is discussed below. When they are used to provide service outside the primary service area, they should be accorded secondary status in the same way that translators historically have been. Since the characteristics of secondary treatment of translators are well understood, they will not be dealt with further herein.

When boosters are used as part of a distributed transmission system to provide service to areas within a station's primary service area, they should be given primary status along with the station's main transmitter. Such use might be for purposes of reaching otherwise unreachable locations, for providing increased signal levels in a portion of the service area, or for other, perhaps similar reasons. Treatment as primary facilities is required now where it was not required under the old NTSC Rules because of the change from determining protection only to predicted contours before to determining protection to individual, small cells within predicted contours now. Once interference is determined within the boundaries of the contours, methods must be available to protect the actual service delivered, and that service will include signals from distributed transmission systems and boosters. Hence the boosters in such cases must be treated as primary.

Booster locations and service areas

Boosters can be used as part of distributed transmission systems for purposes including filling in service within previously defined contours and maximizing service by reaching new areas. These are the cases in which boosters should be treated as primary facilities. (To aid the discussion, such boosters will be described as "primary boosters.") When used for such applications, it is necessary to appropriately define both the locations in

which boosters can be placed and the service area of a station with which boosters are so used.

There are three cases that must be considered in determining where primary boosters can be located. First, there is the situation in which a station uses its reference transmitter site, as contained in the original DTV Table of Allotments as amended, for its main transmitter location. Second, there is the situation in which a station establishes a main transmitter location at a substantial distance from the original reference transmitter site. In the latter case, it is assumed that the new transmitter site meets the criteria outlined above for service replication in terms of reaching 90 percent of the population of the station's NTSC Noise Limited population. Third, there is the situation in which a station establishes a main transmitter location at a substantial distance from the original reference transmitter site that does not meet the replication requirements. For each of these cases, it is proposed that primary boosters be required to be located within the appropriate DTV service contours.

In the case of a station that uses its original reference transmitter site, the boosters should be located within either the noise limited contour of its original reference facilities as included in the Table of Allotments or its expanded noise limited contour as obtained through maximization of its facilities. The appropriate contour is whichever extends further in the direction of the booster from the reference location.

In the case of a station that has established a main transmitter location different from its reference facilities but providing full replication as defined previously, the boosters should be located within the combined noise limited contour of its reference facilities and noise limited contour of its moved facilities. This is comparable to the use of the maximized contour in the previous case and allows service to be offered to populations within its NTSC Noise Limited contour that might otherwise be outside the service contour of the moved facilities. It would allow increasing the percentage of replication.

In the case of a station that has established a main transmitter facility different from its reference facilities that does not provide full replication, the boosters should be located within the noise limited contour of the original reference facilities. This will allow the

station to provide service within the reference noise limited contour and to maximize that contour to the extent described below in the subsection on Noise Limited Contours. This case is the situation of a distributed transmission system in which all the transmitters are essentially the same in their characteristics; one of them, presumably the one closest to the original reference point, must be designated as the "main" transmitter for reference purposes.

Noise-limited contours

Once primary boosters are located within the appropriate noise limited contours, as described immediately above, then it is necessary to define the areas they are permitted to serve. This ultimately also has implications for the technical parameters they are allowed to be given. Service from primary boosters can be defined in two ways: in terms of the noise limited contours they produce and in terms of the populations they reach as indicated typically by a Longley-Rice type of analysis. In the case of defining service for limiting the facilities to an appropriate level, the noise-limited contour is the correct method as it is the same as used elsewhere for the same purpose. In the case of defining service for interference analyses, then the Longley-Rice analysis is the correct method for similar reasons.

For the purpose of defining the permitted service from boosters, it should first be understood that the noise limited contours from boosters situated as defined in the previous subsection will extend beyond the noise limited contours of the reference or maximized facilities. The question then becomes by how much boosters located near the edges of service areas should be permitted to extend those service areas. It is submitted that a booster should be permitted to extend by 50 percent the distance from the original or moved reference location to the furthest contour used to define permissible locations for boosters in the direction of the extension. The reference locations intended for this purpose are the original reference site from the Table of Allotments in the first and third cases described previously and the moved reference site in the second, full replication case.

Interference considerations

Interference considerations with respect to distributed transmission systems and boosters must deal with both directions. Interference must be analyzed from the distributed transmission systems into neighboring systems and from neighboring systems into the distributed transmission systems. Analysis of the interference to neighbors is a fairly straightforward modification of the process already in place, while analysis of the interference from neighbors requires a bit more modification of the existing processes but is based on them nonetheless. In both cases, the Commission's Longley-Rice analysis procedures as spelled out in OET-69 and the *de minimis* limitation criteria are proposed.

Regarding interference protection to neighbors, it is necessary to assure that the distributed transmission system causes no more than the allowed 2 percent reduction in population served by a neighboring station, with a total of no more than 10 percent reduction by all stations. The distributed transmission system to be analyzed comprises the main transmitter and all primary boosters. To analyze the impact of the distributed transmission system on a neighbor, the neighbor's service is analyzed two ways. First the neighbor is analyzed with the reference facilities from the amended original Table of Allotments included in the analysis and the distributed transmission system not included. Then the neighbor is analyzed in reverse fashion, with all the transmitters of the distributed transmission system included and the reference facilities from the amended original Table of Allotments not included (unless they are also included as part of the distributed transmission systems design). The two analyses are compared in the same way as normally done for single-transmitter stations and a determination made about the meeting of the *de minimis* criteria. This process can be implemented with existing software that has been developed for interference analysis of conventional situations.

For interference protection from neighbors to distributed transmission systems, it is necessary to measure the *de minimis* impact of the neighbors on the system as a whole. To do so requires recognition that a given location within the distributed transmission system's service area may be served by more than one transmitter. An interfering station could conceivably deliver a strong enough signal to a particular location to interfere with the signals from several of the transmitters in the distributed transmission system. If each

transmitter in the system were analyzed individually, double counting of interference losses would result. To avoid double counting, it is necessary to analyze the neighbor's interference so that interference to any particular location is not considered to occur if any of the distributed transmission system's transmitters can deliver a signal to that location with an adequate D/U. Even when none of the transmitters in the distributed transmission system can deliver a signal with an adequate D/U ratio to a particular location, that location should only be counted once in accumulating the population losses for the *de minimis* calculation. To accomplish this avoidance of double counting, it is necessary to lay down a single grid of analysis cells, as used in the Longley-Rice method of OET-69, to determine the interference to all of the transmitters in the distributed transmission system. The cells would be laid out based upon the reference point for the entire system – either the main transmitter or the reference coordinates from the amended original Table of Allotments. Boosters would have to be linked to the system in the FCC database so that interference analysis computer software could identify all the elements in a system. Discussion of this matter with the supplier of the Commission's software for such analyses (who also supplies this commenter with similar software) indicates that the modifications just described can be made to the existing software as an extension and without requiring a major overhaul of the program.

One other form of interference requires recognition in deciding how to analyze interference from neighbors. That is the interference that occurs within the system between transmitters that are part of the system. It will occur if all that is considered are D/U ratios. As discussed previously, however, there are several techniques that can be used to mitigate such internal interference. They include timing of the transmitters' emissions to take advantage of receiver characteristics, use of terrain shielding, and the like. Application of such mitigation techniques may improve over time as a system is better understood and adjusted. For purposes of the interference analysis from neighbors, internal interference within a system should be ignored, i.e. treated as though it does not exist, when calculating meeting of the *de minimis* limits.

Permissible technical parameters

It should be the objective for the changes proposed herein to place as few limitations as possible on the technical parameters of the various system elements to be used in distributed transmission systems. It is proposed, therefore, that limitations on effective radiated power, antenna height, directional antenna patterns, and the like be only those imposed on main stations under the Commission's current Rules. Those limitations combined with the interference protection requirements and the limitations on extensions of noise limited contours should serve adequately to control use of primary boosters. It is also important in determining the coverage of primary boosters that use of heavy beam tilt be both allowed and recognized in the calculations. Beam tilt will be an important technique for delivering stronger signals near the outer reaches of a station's service area without overly extending the noise limited contour.

Adaptive equalizer performance and alternative modulation methods

In discussing the design of distributed transmission systems earlier in these comments, certain assumptions were made about the performance that can be expected from the adaptive equalizers that are needed in receivers for conventional digital modulation techniques. Those assumptions included the capability in receivers to handle echoes that are relatively long and strong or that lead the main signal. Indications are that the receiver industry is moving in a direction in its designs that will accommodate longer, stronger, and leading echoes. This may take some time but seems that it will occur before there is a large uptake of receivers by consumers. If it is not successfully accomplished, there will be bigger problems that will need to be addressed, perhaps through adoption of an alternate modulation system of the sort the Commission has under consideration in the current proceeding. If such a change in modulation were to occur, the same considerations as discussed in the remainder of this document would continue to apply. In fact, the author of these comments has written extensively on these techniques in combination with the alternative modulation approach[6]. As mentioned previously,

[6] S.M. Weiss, Part 7 – "Distributed Transmission" pp. 207-220 and Part 8 – "Coded Orthogonal Frequency Division Multiplexing" pp. 221-252 in "Issues in Advanced Television Technology," Focal Press, Boston, 1996.

there are techniques in design of the transmission system that can be applied to minimize the burdens placed on the adaptive equalizers in receivers, and they also help ameliorate the impact on receivers for modulation systems that do not necessarily use adaptive equalizers.

The Merrill Weiss Group

By: _____

S. Merrill Weiss
Senior Partner

Merrill Weiss Group
908 Oak Tree Avenue
Suite A
South Plainfield, NJ 07080-5100
Phone: 908 226 8880
Fax: 908 226 8882
e-mail: <merrill@mwgrp.com>